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DOCKET NO: 534P007

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE



In Re Application  
of: Werner Böhnstedt and J. Kevin Whear

Serial No.: Not yet assigned  
Group Art Unit: Not yet assigned  
Filing Date: Herewith by Express Mail  
Examiner: Not yet assigned

For: BATTERY SEPARATOR PROVIDED WITH A PLURALITY OF STUDS AND  
VERTICAL RIBS

EXPRESS MAIL LABEL NO.: EJ861864695US  
DATE OF DEPOSIT: August 11, 1999

BOX: ☒ Patent Application  
☐ Provisional ☐ Design ☐ Sequence

Assistant Commissioner for Patents  
Washington, D.C. 20231

Sir:

PATENT APPLICATION TRANSMITTAL LETTER

Transmitted herewith for filing, please find:

☒ A Utility Patent Application.

If this is a continuing application, please check appropriate  
box:

☐ Continuation ☐ Divisional ☐ Continuation-in-part  
of prior application U.S. Serial No. \_\_\_\_\_ filed  
\_\_\_\_\_

☐ A Design Patent Application.

DOCKET NO: 534P007

Including the following:

☐ Provisional Application Cover Sheet.

☐ New or Revised specification, including pages ☐  
containing:  
☐ Specification  
☐ Claims  
☐ Abstract

☐ A copy of earlier application Serial No. ☐ Filed ☐ to which no new matter has been added, TOGETHER WITH a copy of the executed oath or declaration for such earlier application and all drawings and appendices. Such earlier application is hereby incorporated into the present application by reference.

☐ A copy of executed oath or declaration for earlier application Serial No. ☐ Filed ☐. The entire disclosure of such earlier application is considered as being part of the disclosure of the present application and is hereby incorporated into the present application by reference.

☐ Please enter the following amendment to the Specification under the Cross Reference to Related Applications section (or create such a section): "**This application is a** "

☐ Signed Statement attached deleting inventor(s) named in the prior application.

☐ Preliminary Amendment is enclosed.

☒ **THREE (3)** Sheet(s) of Drawings.

☐ Petition to Accept Photographic Drawings.  
☐ Petition Fee

☒ An ☐ Executed ☒ Unexecuted Declaration or Oath and Power of Attorney.

☐ An Associate Power of Attorney.

☐ An Executed Assignment of the Invention to:  
☐

☐ A Recordation Form Cover Sheet.  
☐ Recording Fee - \$40.00.

DOCKET NO: 534P007

- \_\_\_\_ Priority is claimed under 35 U.S.C. §119 of application no: \_\_\_\_\_ filed \_\_\_\_\_ in \_\_\_\_\_
- \_\_\_\_ A certified copy of the foregoing application for which priority is claimed:
- \_\_\_\_ is enclosed.
- \_\_\_\_ will be submitted in due course
- \_\_\_\_ was filed in prior application Serial No. \_\_\_\_\_  
filed \_\_\_\_\_
- \_\_\_\_ was transmitted by the International Bureau under International Application No. \_\_\_\_\_ filed \_\_\_\_\_
- \_\_\_\_ An \_\_\_\_\_ Executed \_\_\_\_\_ Copy of Earlier Statement Claiming Small Entity Status under 37 C.F.R. 1.9 and 1.27
- \_\_\_\_ is enclosed.
- \_\_\_\_ has been filed in prior application Serial No. \_\_\_\_\_  
filed \_\_\_\_\_, said status is still  
proper and desired in present case.
- \_\_\_\_ Diskette Containing DNA/Amino Acid Sequence Information.
- \_\_\_\_ Statement to Support submission of DNA/Amino Acid Sequence Information.
- \_\_\_\_ Letter of Reference to Computer Readable Form.
- \_\_\_\_ Information Disclosure Statement.
- \_\_\_\_ Attached Form 1449.
- \_\_\_\_ Copies of each of the references listed on the attached Form PTO-1449 are enclosed herewith.
- \_\_\_\_ Petition for Extension of Time for parent application, Together with the appropriate extension fee.
- \_\_\_\_ Appended Materials as follows: \_\_\_\_\_.
- X Return Receipt Postcard specifically itemized.
- \_\_\_\_ Other as follows:

DOCKET NO: 534P007

FEE CALCULATION	<u>BASIC FEES</u>
Provisional Application	\$150.00
Design Application	\$310.00
Utility Application	\$760.00

For	Number Filed	Number Extra	Rate	Fee
Basic Fee				\$ 760.00
Total Claims	14 - 20	0	x \$18.00	= \$ 0.00
Independent Claims	1 - 3	0	x \$78.00	= \$ 0.00
Multiple Dependent Claims			+ \$260.00	= \$ 0.00
TOTAL FILING FEES				\$ 760.00*

\*The Filing Fee will be submitted in due course, together with the executed Declaration and the surcharge for late filing.

\_\_\_\_\_ A Check is enclosed in the amount of \_\_\_\_\_.

\_\_\_\_\_ The Commissioner is authorized to charge payment of the following fees and to refund any overpayment associated with this communication or during the pendency of this application to deposit account \_\_\_\_\_. This sheet is provided in duplicate.

\_\_\_\_\_ The foregoing amount due.

\_\_\_\_\_ Any additional filing fees required, including fees for the presentation of extra claims under 37 C.F.R. 1.16.


\_\_\_\_\_ Any additional patent application processing fees under 37 C.F.R. 1.17 or 1.20(d).

\_\_\_\_\_ The issue fee set in 37 C.F.R. 1.18 at the mailing of the Notice of Allowance.

DOCKET NO: 534P007

SHOULD ANY DEFICIENCIES APPEAR which respect to this application, including deficiencies in payment of fees, missing parts of the application or otherwise, the United States Patent and Trademark Office is respectfully required to promptly notify the undersigned.

Date: August 14, 1999

  
\_\_\_\_\_  
Kevin S. Lemack  
Registration No. 32,579  
Niels, Lemack & Dingman  
176 E. Main Street - Suite 8  
Westboro, Massachusetts 01581  
TEL: (508) 898-1818  
FAX: (508) 898-2020

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of: **Werner Böhnstedt and J. Kevin Whear**

For: **BATTERY SEPARATOR PROVIDED WITH A PLURALITY OF STUDS AND VERTICAL RIBS**

Assistant Commissioner of Patents and Trademarks  
Washington, D.C. 20231

Sir:

LETTER

The above-identified applicants enclose for filing a patent application entitled "**BATTERY SEPARATOR PROVIDED WITH A PLURALITY OF STUDS AND VERTICAL RIBS**". Said attached patent application includes (1) Patent Application Transmittal Letter (5-Pages); and (2) Patent Application: 14-Page Specification (including 2-Pages of Claims (14) and 1-Page Abstract), 3-sheets of A4 size drawings and an unexecuted Declaration and Power of Attorney (1-Page).

All correspondence concerning this application should be mailed to:

**Kevin S. Lemack  
Niels & Lemack  
176 E. Main Street - Suite 8  
Westboro, Massachusetts 01581**

Respectfully submitted,



Kevin S. Lemack  
Attorney for Applicant  
Registration No. 32,579

Date: August 11, 1999

Battery separator provided with a plurality  
of studs and vertical ribs

FIELD OF THE INVENTION

This invention relates to separators for electric lead acid storage batteries.

BACKGROUND OF THE INVENTION

Lead acid storage batteries typically comprise a plurality of positive and negative electrode plates separated from another by thin microporous sheets. These separators serve to separate, i.e. to electrically isolate the electrode plates. They are usually provided with a plurality of ribs to prevent a direct contact of the separator sheet in particular with the positive electrode plates. While in use oxygen is generated at the positive plates during charging which oxidizes the separator material thus causing deterioration of the separator with subsequent short-circuiting between the positive and negative plates.

However, such ribs increase the electric resistance and acid displacement of the separator thereby reducing the discharge capacity of the battery. Also, rib require the use of additional material and therefore increase the production costs of the separator. Moreover, ribs may contribute to problems such as misalignments during pocketing of the electrode plates which, in turn, can result in puncture of the separator sheet by sharp edges of the electrodes thus causing a significant reduction in the useful life of the battery.

In order to reduce the electrical resistance, acid displacement and raw material costs US 5,558,952 suggests separators having a plurality of broken discontinuous ribs in the center of the separator sheet. It was found that profiles with interrupted vertical ribs tend to generate problems in the production of separator pockets in that a so-called "cushion effect" is observed. In addition, broken ribs with short elevated parts cannot prevent a direct contact of the edges of the electrode plates with the separator sheet.

Furthermore, dimpled separator profiles have been suggested to reduce electrical resistance and acid displacement. In these profiles the separator is provided with a pattern of dimples evenly distributed over the separator sheet. These profiles have never gained commercial interest.

#### SUMMARY OF THE INVENTION

The present invention relates to a battery separator for a lead acid storage battery comprising a porous sheet provided with a plurality of studs and at least one elongated vertical rib on at least one side of the sheet. The at least one elongated vertical rib is arranged in the center area of the sheet and, if the separator comprises studs on one side only, is present on the same side as the studs, i.e. the separator comprises at



least one elongated vertical rib in the center area of at least one side of the sheet provided with a plurality of studs.

It is the object of the invention to provide a battery separator for a lead acid storage battery which has a reduced electrical resistance, a reduced acid displacement, and a reduced raw material requirement without showing the disadvantages of known separators.

It is a further object of the invention to provide a separator that reliably maintains electrode distance during use, ensures a high cycle life of the battery and avoids assembly problems during the pocketing of the electrodes and battery production.

#### BRIEF DESCRIPTIONS OF THE DRAWING

Figure 1 is a isometric view of a separator according to the present invention.

Figure 2 is a partially broken away isometric view of a folded sheet of a separator according to the present invention containing an electrode plate.

Figure 3 is a view in the direction III-III of Figure 1.

#### DETAILED DESCRIPTION OF THE INVENTION

In the following, embodiments of the present invention will be described in detail with reference to the accompanying drawings. Figure 1 shows a separator 1 of the present invention. The separator comprises a porous sheet 2 provided with a plurality of studs 3 having the form of truncated cones and three continuous vertical ribs 4 in the center area 5 of the separator sheet. The studs are also present at the lateral side areas 6.

Figure 2 depicts an electrode plate 7 after it has been inserted in the microporous separator 1 but before sealing the side end portions 6.

The sheet 2 is preferably made of a synthetic resin such as polyolefin, poly(vinyl chloride) or other suitable material which is compatible with the battery environment where it is to be used. The preferred separator material is polyolefin, such as polypropylene, ethylene-butene copolymer, and preferably polyethylene, more preferably high molecular weight polyethylene, i.e. polyethylene having a molecular weight of at least 300,000, even more preferably ultra high molecular weight polyethylene, i.e. polyethylene having a molecular weight of at least 1,000,000, in particular more than 4,000,000, and most preferably 5,000,000 to 8,000,000 (measured by viscosimetry and calculated by Margolie's equation), a standard load melt index of substantially 0 (measured as specified in ASTM D 1238 (Condition E) using a standard load of 2,160 g) and a reduced viscosity of not less than 1,000 ml/g, preferably not less than 2,000 ml/g (determined in a solution of 0.02 g of polyolefin in 100 g of decalin at 130 °C).

The finished separator preferably comprises a homogeneous mixture of 8 to 100 vol.% of polyolefin, 0 to 40 vol.% of a plasticizer and 0 to 92 vol.% of inert filler material. The preferred filler is dry, finely divided silica. The preferred plasticizer is petroleum oil. Since the plasticizer is the component which is easiest to remove from the polymer-filler-plasticizer composition, it is useful in imparting porosity to the battery separator. The final composition of the separator will depend upon the original composition and the component or components extracted. Materials of this kind are well-known in the art and described for example in US 3,351,495 the disclosure of which is incorporated herein by reference.

The microporous separator sheet has a pore size which is generally less than 1  $\mu\text{m}$  in diameter, and preferably more than 50% of the pores are 0.5  $\mu\text{m}$  or less in diameter. It is especially preferred that at least 90% of the pores have a diameter of less than 0.5  $\mu\text{m}$ .

The thickness of the separator sheet is preferably within the range of 0.1 to 0.6 mm, preferably within the range of 0.15 to 0.25 mm and most preferably about 0.2 mm.

The microporous separator sheet is provided on one side of the sheet with a plurality of studs and at least one vertical rib in the center area of the sheet. However, the separator can additionally comprise ribs and/or studs on the other side of the sheet. Preferably the separator comprises a plurality of studs and at least one vertical rib on only one side of the sheet. According to a preferred embodiment the separator contains 2 to 4 vertical ribs, more preferably 2 or 3 vertical ribs.

The ribs preferably have a height of about 0.3 to 1.3 mm, preferably about 0.4 to 0.9 mm and most preferably of about 0.5 mm, and a base width of about 0.5 to 1.5 mm, preferably about 0.7 mm. They may have any suitable cross section with round and triangular cross sections being preferred and trapezoid cross section being most preferred. The height of the ribs may be the same as that of the studs, as illustrated in Figure 3, or may be lower.

The at least one vertical ribs is an elongated rib, i.e. a rib having a length of at least 2 cm. According to a preferred embodiment, the vertical rib(s) have the form of continuous ribs extending across the whole separator sheet as shown in Figure 1.

Separators for starter batteries typically have a width of about 160 mm, electrodes of about 145 to about 148 mm. Prior art separators usually have ribs spaced at a distance of from about 6 to 13 mm. Therefore, a typical separator comprises about 12 to 25 ribs which greatly contribute to the total volume of the separator and thus to the electrical resistance and the acid displacement. Moreover, the rib material constitutes a considerable portion of the total separator material. The separators of the present invention contain one and preferably not more than 4 vertical ribs and since the contribution of the studs to the total volume of the separator is minimal a significant decrease of separator volume, electrical resistance, and acid displacement is achieved. By the separator profile of the present invention the total volume of ribs and studs can be reduced to about 10 % to 30 % of the rib volume of a ribbed separator according to the prior art. Thus, the amount of material needed for the production of the separator and the costs are reduced significantly.

The term "studs" refers to elevated areas rising above the separator sheet 2 and having the form of solid bodies. They have the function of a spacer keeping the separator sheet 2 away from the positive electrode plate 7 and thus prevent a direct contact of the sheet with the electrode.

The studs may have any suitable shape, and preferably have the form of spherical caps, such as semi-spheres and/or truncated pyramids, with truncated cones being most preferred. They preferably have a height of about 0.3 to about 1.3 mm, more preferably about 0.4 to 0.9 mm, and most preferably about 0.5 mm, and a base diameter of about 0.5 to about 1.5 mm, preferably about 0.7 mm.

According to another embodiment the studs have the form of a plurality of non-continuous, broken ribs similar to those disclosed for an instance in US 5,558,952. The elevated parts of

such non-continuous ribs preferably have a length of not more than 1 cm, more preferably of not more than 0.5 cm. The gaps between the elevated parts of the non-continuous ribs preferably have a length of at least about double the length of the elevated parts.

The number of studs is dependant upon the separator material. Typically the separator sheet is provided with about 0.2 to 2 studs per  $\text{cm}^2$  of the sheet surface, preferably about 1 stud per  $\text{cm}^2$ . The maximum distance between two studs is preferably in the range of about 4 to 25 mm. The studs may be arranged aligned, as shown in Figure 1, or alternately or randomly distributed.

The studs and the at least one vertical rib are solid bodies which are preferably integrally formed of the same material as the separator sheet as will be explained later.

The at least one elongated vertical rib is arranged in the center area 5 of the separator sheet, i.e. the part of the sheet being in contact with the electrode plates. The term "center" refers to the horizontally determined middle of the sheet. The studs must also be present in the center area 5 but are preferably also present at the side areas or shoulders 6 of the separator (land areas).

The separators can also comprise a plurality of closely spaced ribs in the lateral side areas 6 of the separator sheet. In this instance, the lateral edges of the separator preferably comprise at least about 10 to 12 ribs per cm as disclosed for instance in EP 0 899 801 A1. Also, the separators may comprise a plurality of short, intersectant, vertically spaced ribs at the lateral side areas of the separator sheet as disclosed for instance in US 5,716,734, or a combination of both closely spaced vertical ribs and intersectant ribs as disclosed in US 5,558,952. If present, such intersectant ribs preferably start

at one of the studs and extend to the left or right edge of the separator sheet. It is also preferred that the height of such intersectant ribs decreases from the inside of the sheet to the outside. At the inner end the ribs may have for instance the same height as the studs, at the outer end the height can be close to zero. The short intersectant ribs may be arranged horizontally or slanted relative to the horizontal line. According to still another embodiment the thickness of the side areas of the sheet may be greater than the thickness of the center area of the sheet e.g. by a factor of 2 as described in European patent specification EP 0 484 295 B1. The above reinforcements of the land areas 6 help to prevent puncture of the separator sheet by edges of the electrode plates. Separators with reinforced side areas 6 preferably do not comprise studs at the side areas 6.

To increase rigidity in transverse direction the separators of the present invention may also be provided with a plurality of continuous transverse ribs as disclosed in US 5,776,630. Transverse ribs preferably have a lower height than the at least one vertical rib.

The separators of the present invention preferably have the form of a pocket with an open top, a closed bottom and closed sides. Such pockets are manufactured basically by molding synthetic resin, alone, or a mixture of synthetic resin with inorganic powder and a pore-forming agent, into a belt-like sheet by means of a molding machine, such as an extruder. The extruded separator material is passed between at least one pair of calender rolls, which form the studs and/or the rib patterns on the length of material. The pore-forming agent is then extracted from the molded sheet by means of a solvent. The sheet is thereafter dried, so that a porous belt-like sheet is obtained. The porous sheet is cut into a number of pieces of a predetermined length and in a rectangular shape. The sheet separator is then folded at the middle, forming two mutually facing sides

with side end portions 6 formed on the left and right margins of the folded sheet separator. A negative or preferably positive electrode plate 7 for lead acid storage battery is then inserted into the folded separator sheet as illustrated in Figure 2 and then the side edges of the separator are sealed together by heat sealing, such as ultrasonic, or mechanical sealing, such as pressure welding, or the like. The sealed portions are formed on opposite side edges of the resulting pocket type separator with the bottom edge formed by the above mentioned folding and the left and right side edges closed, and with an open top side. The formation of pocket separators is well-known in the art.

The above process results in solid ribs and studs formed integrally from the same material as the separator sheet as illustrated in Figure 3. This is a preferred embodiment of the invention. However, it is also possible to form the separator sheet, the studs and/or the ribs in separate steps using the same or different materials. Suitable rib materials include polyethylene, polypropylene, and poly(vinyl chloride). These materials may be unfilled or filled, e.g. with silica or air. The use of air as a filler results in so called "blown ribs". For instance, a separator provided with a plurality of integrally formed studs is formed in a first step and an elongated vertical rib is applied thereto later, e.g. by extrusion. It is evident that in this embodiment the elongated rib can also be applied to the electrode plate instead of the separator sheet. The electrode is then pocketed with the separator comprising the plurality of ribs.

If the at least one vertical rib does not have the form of a continuous rib it is important to arrange the rib not only in the center area of the sheet but also in the bottom edge area of the separator pocket (vertical middle of the unfolded sheet). This can be achieved, for instance, by extruding an elongated rib onto the separator after cutting the separator or

by forming a continuous rib by extrusion, cutting this continuous rib into pieces having a length of not less than 2 cm, and then folding these pieces to provide pieces having a U-form. The U-formed pieces are applied to the bottom edge of the electrode plate which is thereafter pocketed with a separator provided with a plurality of studs.

Although not preferred, such two (or more) piece separators are clearly within the scope of the present invention.

Finally, a plurality of positive electrodes, contained in their respective separators, together with a plurality of negative electrode plates, are assembled into a cell assembly of the lead acid storage battery.

Separator production and manufacturing of pockets are usually performed at different locations. Therefore, it is preferred that the belt-like separator is cut into the width needed for pocket production and then rolled up. These rolls are sold and delivered to the battery manufacturer who cuts the rolled material into pieces for pocket production.

The plurality of studs and the at least one vertical rib of the separators of the present invention are preferably arranged on the side of the separator sheet facing the positive electrode. Thus, in pockets for retaining a positive electrode plate the studs and vertical ribs are provided on the inner surfaces on the pocket. However, additional ribs and studs may be provided on the other surfaces as described above.

The separators of the present invention can be prepared at considerably lower costs than ribbed separators according to the prior art due to a reduced raw material need and higher production speed. They do not show the disadvantages of separators provided with broken ribs, i.e. no cushion effect is observed upon pocket production and a direct contact between



the separator sheet 2 and the electrode edges is reliably prevented. Furthermore, they safely keep the distance between the electrodes and avoid problems during battery assembly thus ensuring a high-cycle life. In addition, it has been found that the separators of the present invention give a higher cold crank power compared to known separators.

Claims

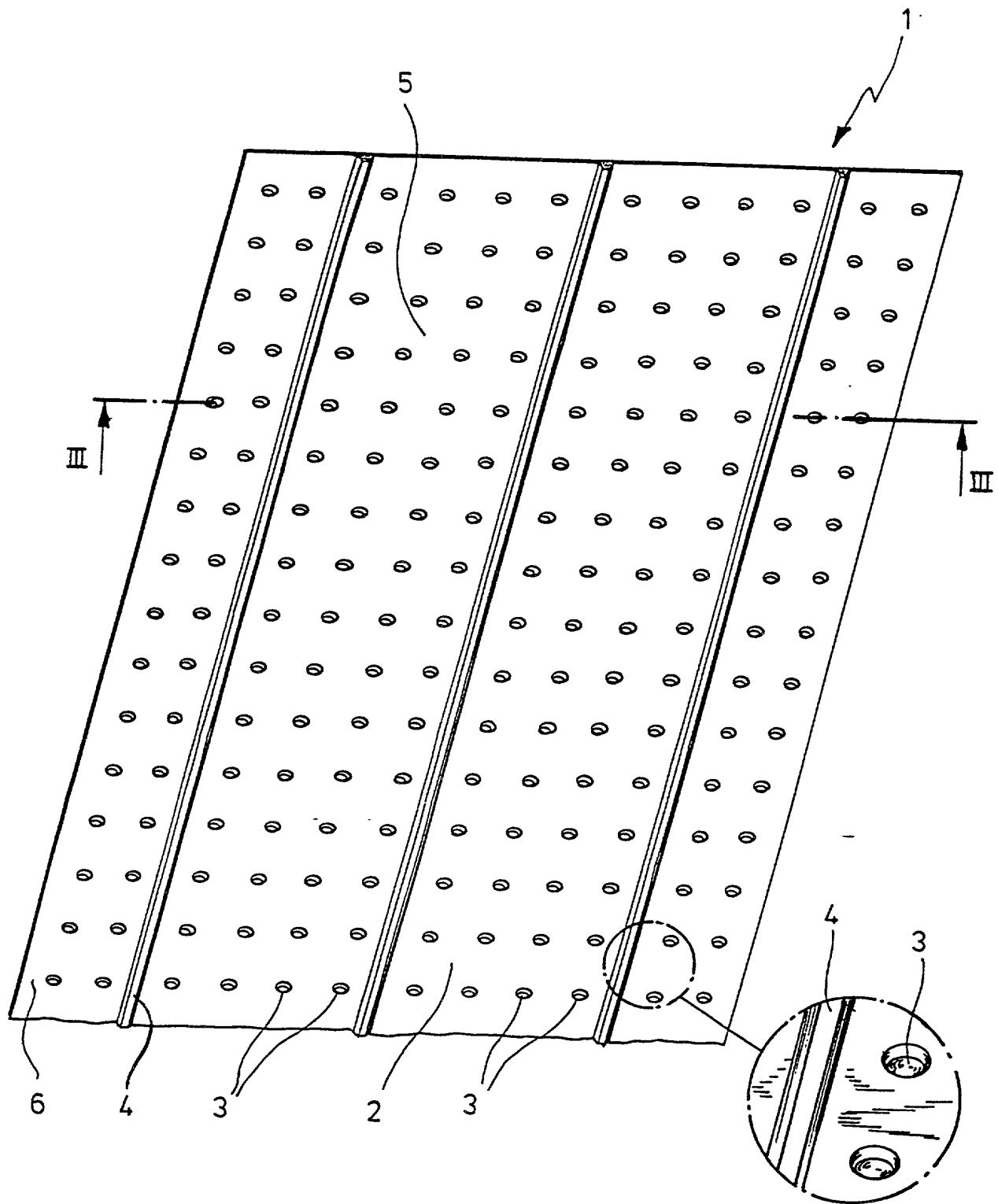
1. A battery separator for a storage battery, said separator comprising a porous sheet having a center area and side areas and being provided with a plurality of studs on at least one side of the sheet, characterized in that the separator additionally comprises at least one elongated vertical rib in the center area of at least one side of the sheet provided with a plurality of studs.
2. The separator as defined in claim 1 wherein the elongated rib is a continuous rib.
3. The separator as defined in claim 1 comprising 2 to 4 elongated vertical ribs in the center area of the separator sheet.
4. The separator as defined in claim 1 wherein the studs have the form of truncated cones, truncated pyramids and/or spherical caps.
5. The separator as defined in claim 1 wherein the continuous ribs have the same or a lower height than the studs.
6. The separator as defined in claim 1 comprising 0.2 to 2 studs per cm<sup>2</sup> of the separator sheet.
7. The separator as defined in claim 1 wherein the studs and the ribs are solid bodies integrally formed of the same material as the separator sheet.
8. The separator as defined in claim 1 wherein the studs and/or the ribs are formed of a different material than the separator sheet.

9. The separator as defined in claim 1 comprising a porous sheet being provided with a plurality of studs on at least one side of the sheet and at least one separate rib applied to the electrode plate.
10. The separator as defined in claim 1 having the form of a pocket with an open top, a closed bottom and closed sides.
11. The separator of claim 10 in which the studs and vertical ribs are provided on the inner surfaces of the pocket.
12. The separator as defined in claim 10 wherein the at least one elongated rib is arranged in the bottom edge area of the separator pocket.
13. The separator of claim 1 provided in form of a roll.
14. A lead acid storage battery comprising at least one separator according to claim 1.

ABSTRACT

A battery separator for a lead acid battery which comprises a porous sheet having a center area and side areas and which is provided with a plurality of studs on at least one side of the sheet and additionally comprises at least one continuous vertical rib in the center area of the same side of the sheet.

FIG. 1



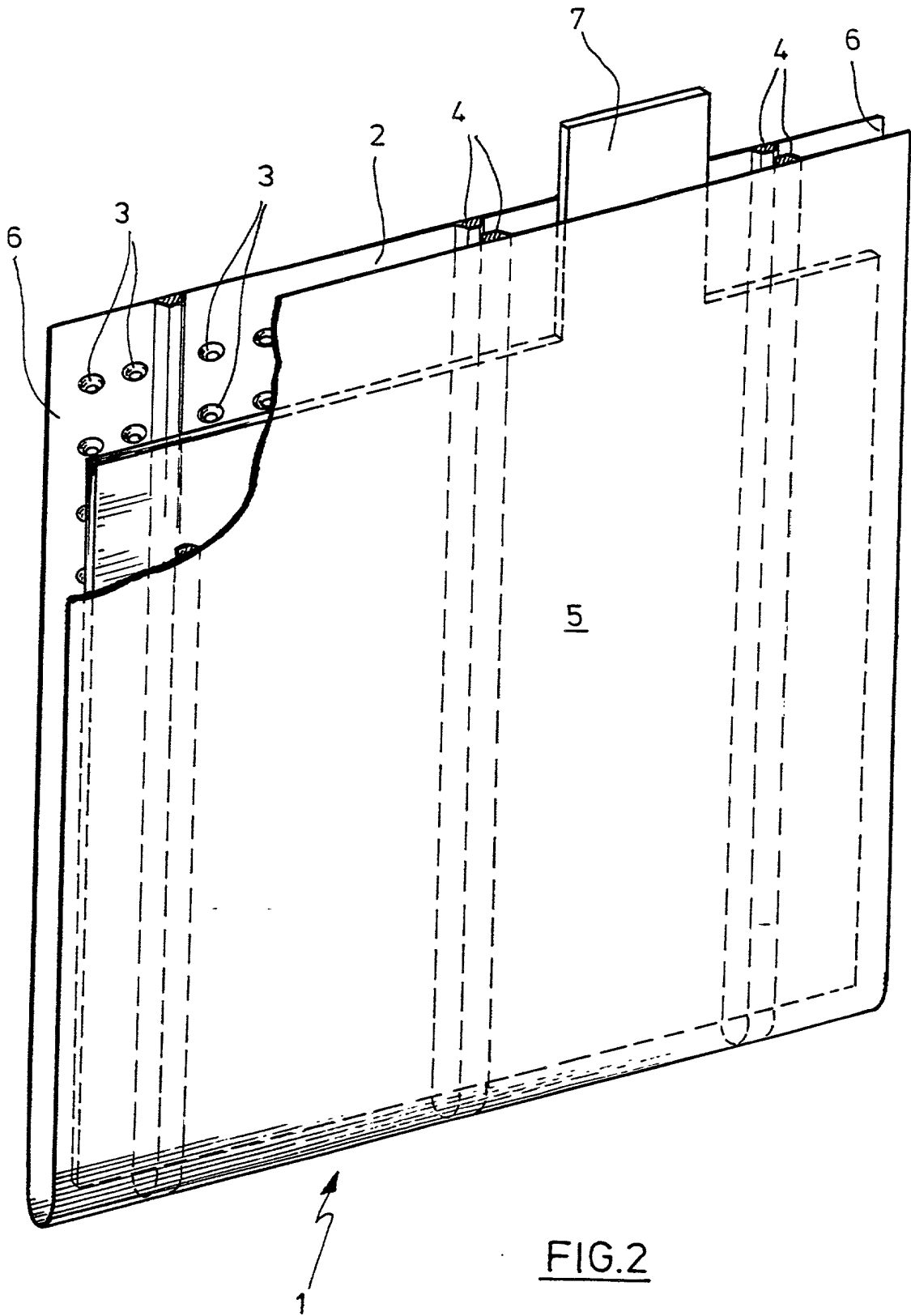


FIG.2

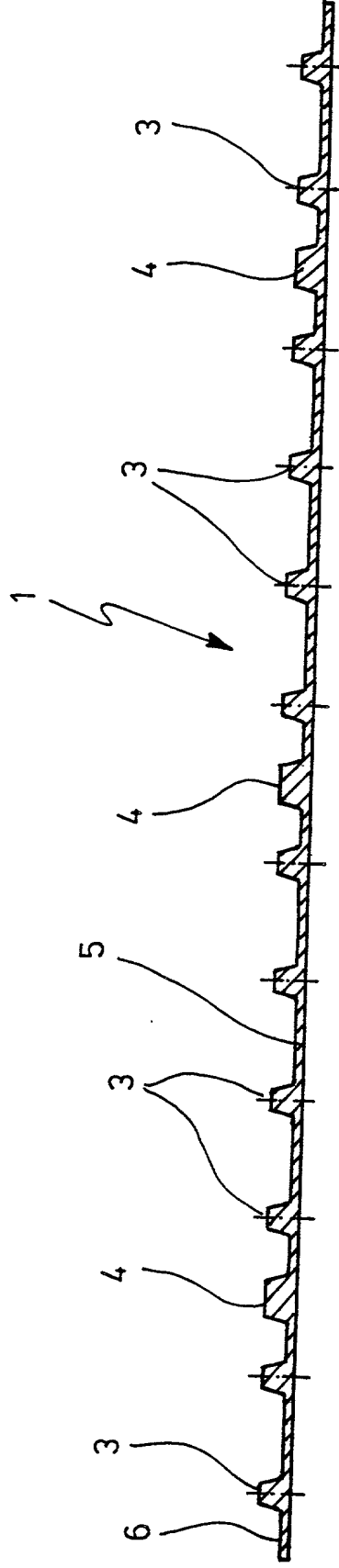


FIG. 3

## DECLARATION FOR PATENT APPLICATION

Docket Number (Optional)

534P007

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

BATTERY SEPARATOR PROVIDED WITH A PLURALITY OF STUDS AND VERTICAL RIBS  
is attached hereto unless the following box is checked:

☐ was filed on \_\_\_\_\_ as United States Application Number or PCT International Application Number \_\_\_\_\_ and was amended on \_\_\_\_\_ (if applicable)

I hereby state that I have reviewed and understand the contents of the above identified specification including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR § 1.56.

I hereby claim foreign priority benefits under 35 U.S.C. § 119(a)-(d) or § 365(b) of any foreign application(s) for patent or inventor's certificate, or § 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or PCT International application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application(s)

Priority Not Claimed

_____ (Number)	_____ (Country)	_____ (Day/Month/Year Filed)	<input type="checkbox"/>
_____ (Number)	_____ (Country)	_____ (Day/Month/Year Filed)	<input type="checkbox"/>

I hereby claim the benefit under 35 U.S.C. § 119(e) of any United States provisional application(s) listed below

_____ (Application Number)	_____ (Filing Date)
_____ (Application Number)	_____ (Filing Date)

I hereby claim the benefit under 35 U.S.C. § 120 of any United States application(s), or § 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. § 112.

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR § 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application

_____ (Application Number)	_____ (Filing Date)	_____ (Status -- patented, pending, abandoned)
_____ (Application Number)	_____ (Filing Date)	_____ (Status -- patented, pending, abandoned)

I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith:

Kevin S. Lemack, Reg. No. 32,579  
Henry C. Nields, Reg. No. 17,029 and Brian M. Dingman, Reg. No. 32,729

Address all telephone calls to Kevin S. Lemack at telephone number (508) 898-1818  
Address all correspondence to Kevin S. Lemack  
Nields, Lemack & Dingman  
176 E. Main Street - Suite 8  
Westboro, Massachusetts 01581

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full name of sole or first inventor (given name, family name) Werner Böhnstedt  
Inventor's signature \_\_\_\_\_ Date \_\_\_\_\_  
Residence Henstedt-Ulzburg, Germany Citizenship Germany  
Post Office Address Rheinikatenweg 13, 24558 Henstedt-Ulzburg, Germany

Full name of second joint inventor, if any (given name, family name) J. Kevin Whear  
Second inventor's signature \_\_\_\_\_ Date \_\_\_\_\_  
Residence Owensboro, Kentucky Citizenship U.S.A.  
Post Office Address 2631 Holland Drive, Owensboro, Kentucky 42303

☐ Additional inventors are being named on separately numbered sheets attached hereto.